Unit 6: Introduction to the Atom

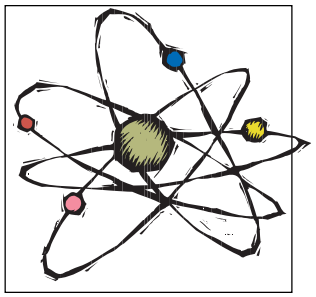
This unit describes the basic structure of an atom and how the atomic model has changed over time. Students will identify the parts of an atom and the charges. Students review the difference between an atom, a compound, and a molecule.

Student Goals

- Define these terms: atoms, molecules, protons, neutrons, nucleus, and electrons.
- Create, through laboratory activities, simple models of molecules.
- Describe the structure of an atom and the behavior of charged particles.
- Locate protons, electrons, and neutrons in an atom model.
- Recognize that the properties of substances are based on the molecular forces.
- Describe how the atomic model has changed over time.

Unit Focus

- Know that from time to time, major shifts occur in the scientific view of how the world works, but that more often, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. (SC.H.1.4.2)
- Understand that no matter how well one theory fits observations, a new theory might fit them as well or better, or might fit a wider range of observations, because in science, the testing, revising, and occasional discarding of theories, new and old, never ends and leads to an increasingly better understanding of how things work in the world, but not to absolute truth. (SC.H.1.4.3)



- Know that the number and configuration of electrons will equal the number of protons in an electrically neutral atom and when an atom gains or loses electrons, the charge is unbalanced. (SC.A.2.4.1)
- Know that the vast diversity of the properties of materials is primarily due to variations in the forces that hold molecules together. (SC.A.1.4.2)
- Know that a change from one phase of matter to another involves a gain or loss of energy. (SC.A.1.4.3)
- Know that electrical forces exist between any two charged objects. (SC.C.2.4.2)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

atom ..... the smallest unit of an element that is still that element; the basic building block of matter

attract ..... move toward each other

bond ..... the attraction that holds two or more atoms together

charge ..... a property of an object that causes it to be affected by a magnetic field

compound ..... a substance formed when two or more elements combine chemically

electron ..... the negatively charged particle of an atom; the electron moves around the center of the atom (nucleus)

element ..... a substance that cannot be broken down into a simpler form by ordinary chemical means

energy level ..... most likely location where the electron can be found around the center of the atom; any of the possible energies an electron may have in an atom

molecule ..... two or more atoms that have a bond of shared electrons

negative charge ..... the charge of an electron

neutral ..... being neither positively nor negatively charged

neutron ..... the neutral particle found in the nucleus of an atom; a neutron has no charge

nucleus ..... the center region of an atom around which the electron(s) move

orbital ..... regions in an atom where electrons are found

positive charge ..... the charge of a proton; considered opposite of negative

proton ..... the positively charged particle in the nucleus of an atom

repel ..... push away from

theory ..... an explanation that has been tested by repeated observations

Introduction

Did you ever wonder what is in air? Have you ever thought about how there are an incredible number of different things in the world? All that you see, touch, and feel is made from tiny units of matter. This unit will introduce you to these unseen building blocks of the universe.

Did you ever wonder what is in air?

Elements

There are thousands and thousands of different substances in the world. Water is a substance. Sugar is a substance. Oxygen is a substance. All of the substances that we know are made of **elements**. The *elements* are the substances that have unique chemical and physical properties. Elements cannot be broken down into other substances that are unique. Of water, sugar, oxygen, which is the element? One way to find out is through chemistry. If we break down the water, we will get hydrogen and oxygen gas. If we break down the sugar, we get hydrogen, oxygen, and carbon. We cannot use chemistry to break down the oxygen. This means that oxygen is the element. Oxygen is a part of such substances as water, sugar, carbon dioxide, rust, and wood.

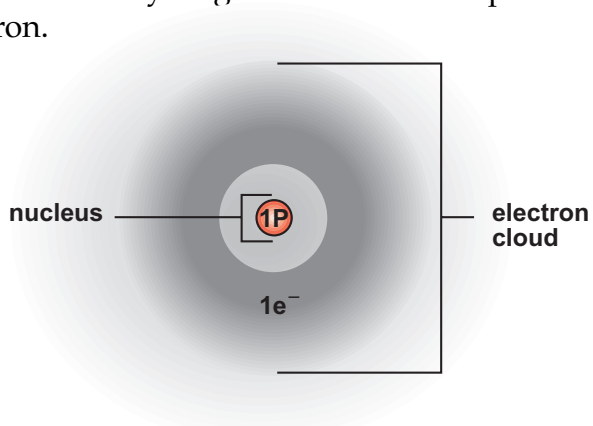
If we break down water, we get hydrogen and oxygen gas.

Atoms

All substances are made of **atoms**. *Atoms* are very tiny pieces of matter. An atom is the smallest unit of an element that is still that element. This may sound strange, but what it means is that an atom of gold is still gold. You cannot see that atom of gold. You cannot feel it. Despite this, it still has the physical and chemical properties of gold. Atoms still have all the properties of the element. An atom is the smallest unit of an element that can go through a chemical change.

Protons and **neutrons** are located in the center region of an atom. This center region is called a **nucleus**. **Electrons** move around like a cloud encircling the outside of a *nucleus*. The number of *electrons* is equal to the number of *protons* in an atom. The number of protons and electrons an atom has is unique for each element. The hydrogen atom is the simplest atom, with one proton and electron.

An atom can gain or lose electrons, a process which can then change its **charge**. Electrons are negatively *charged* particles. If an atom gains extra electrons, it will become **negatively charged** (–). A loss of electrons will create a **positive charge** (+).



One model of the hydrogen atom.

Like other scientific models and theories, the model of the atom has changed to keep pace with new discoveries. Above is one model of the hydrogen atom.

Putting an Atom into Perspective

Let's put the size of a hydrogen atom into perspective. Look at this dash -. The dash is about one millimeter in length. It would take 20 million hydrogen atoms to equal the length of the dash.

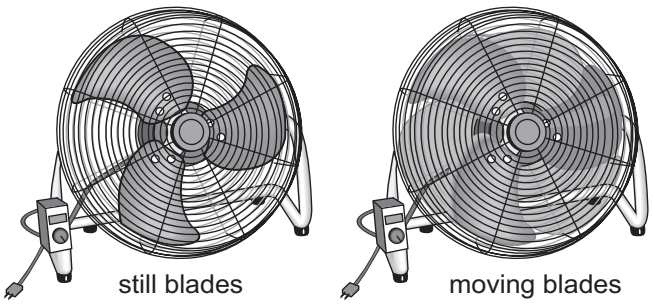
An atom is more than 99% empty space. Protons and neutrons make up a very small amount of an atom's volume. Protons and neutrons are 1,800 times larger than its electrons. The electron actually spins very far away from the nucleus. If the model of the hydrogen atom above was drawn to scale

- the electron would be spinning about a quarter mile away from the nucleus.
- the proton would be the size of the Giants Stadium in New Jersey.

Protons and neutrons behave like small particles, sort of like tiny billiard balls. Although electrons are sometimes shown as small particles spinning around a nucleus, that model is a bit misleading. Electrons are more like

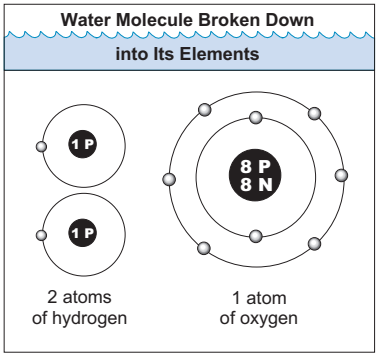
waves on a vibrating string than particles. The most probable location of electrons around the nucleus is in the *electron cloud*. (An electron cloud is not actually a cloud.)

As you can see in the model of a hydrogen atom on the previous page, its proton is surrounded by an electron cloud. You can compare an electron cloud to the blurred area you see when you look at the swiftly moving blades of a fan. You cannot tell the exact location of one blade, but you do know the blade is within the blurred area. The same is true with electrons around a nucleus; you only know their probable location.



You can compare an electron cloud to the blurred area you see when you look at the swiftly moving blades of a fan. You cannot tell the exact location of one blade, but you do know the blade is within the blurred area.

There are about 118 different elements. So, there are about 118 different kinds of atoms. These atoms can combine with each other and form many different kinds of substances. One substance made from atoms combining is water. Water is made of two atoms of hydrogen and one atom of oxygen. (Although it is more accurate to show electrons in electron clouds, we will use the following model.)



Within electron clouds, electrons are at various distances from the nucleus. These distances are called **energy levels**.

- Electrons close to the nucleus have low energy.
- Electrons farther away from the nucleus have high energy.

Hydrogen has one *energy level* of electrons. There is only one electron in the *energy level*. The other, larger atom is a similar model of oxygen. Oxygen has two energy levels. The outer energy level has six electrons.

In the next section we will talk about how these atoms combine. When two or more atoms combine, a chemical change takes place.

Practice

Use the list below to complete the following statements.

atom	**elements**	**neutrons**
charge	**energy levels**	**nucleus**
electrons	**negatively charged**	**positive charge**

1. All of the substances that we know are made of _____ which have unique chemical and physical properties.

2. A(n) _____ is the smallest unit of an element that is still that element.

3. Protons and _____ are located in the nucleus.

4. An atom can gain or lose _____ , a process which can then change its _____ .

5. Electrons are negatively *charged* particles that move around in a cloud encircling the outside of a _____ .

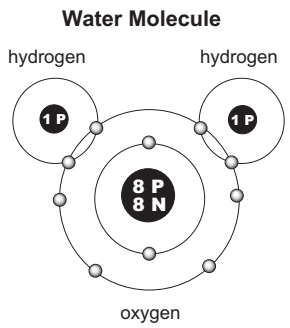
6. If an atom gains extra electrons, it will become _____ .

7. A loss of electrons will create a _____ .

8. Within electron clouds, electrons are at various distances from the nucleus. These distances are called _____ .

Molecules

A **molecule** is formed when atoms share electrons. In chemical reactions, only electrons are involved. This is because only electrons are on the outside of the atoms. Because its electrons are shared, a *molecule* is always made of two or more atoms.



Look at the diagram of a water molecule on the left. It has two hydrogen atoms and one oxygen atom. Notice where the electrons are in the diagram of the water molecule. Each hydrogen atom has its own electron, but each now shares an electron with oxygen. Oxygen has six electrons in its outer energy level. Oxygen now shares electrons with the hydrogen atoms. Because these three atoms are sharing electrons, they form a molecule. Water is the substance made of molecules that have two hydrogen atoms and one oxygen atom.

Some molecules are not made of different types of atoms. For instance, the element chlorine is often seen as a molecule. In this case, two atoms of chlorine share electrons. Even though chlorine is often a molecule, it is still an element. Why is this? **Bonds** are the attraction that hold two or more elements together. If you broke the *bonds* between the water, you would have two gases (hydrogen and oxygen) which are very different from water. If you broke the *bonds* between chlorine atoms, you would still have chlorine. Chlorine is just one of the elements that commonly form molecules. In fact, both oxygen and hydrogen atoms will form molecules when not bonded to other atoms. Now that you know what a molecule is, the next section will discuss **compounds**.

Compounds

A *compound* has two or more atoms of different kinds. Oxygen, remember, is an element. Its molecules are made of two atoms of oxygen. Water, however, is a compound. Its molecules are made of two atoms of hydrogen and one atom of oxygen. The behavior of molecules is determined by the forces holding the molecules together. The molecules in matter help explain the differences between solids, liquids, and gases. In a solid, the molecules are very close together. They cannot move around very easily. The molecules in a liquid are further apart and can move

easily. In a gas, the molecules are very far apart. They can move freely. That's why the molecules of a gas always can fill a container.

When matter changes phase, the distance between the molecules changes. Gaining heat usually causes the molecules to move apart. This may cause melting. Freezing, which is a loss of heat energy, causes the molecules to slow down and move closer together.

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Reviewing the Atom

Think about what you have learned about the atom. The atom is the smallest unit of an element. An atom of silver still has all the properties of silver. You should also remember that atoms can combine with other atoms to form molecules and compounds.

History of the Atom

How did humans learn about the atom? Atoms are too small to be seen. But as long as 2,000 years ago, the Greeks were curious about matter. They wondered how it was made. Many guesses were made about the atom. At first they guessed that atoms could not be divided into smaller pieces. Today we know that is not true, but these early ideas helped scientists study atoms.

About 150 years ago, an English chemist named John Dalton studied atoms. His **theory** about atoms stated the following:

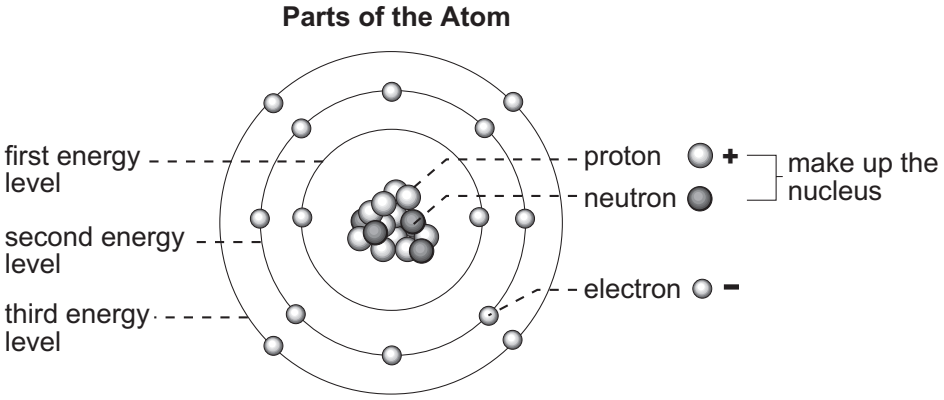
- Elements are made of atoms.
- All atoms in an element have the same mass.
- Atoms cannot be split apart.
- Atoms combine with atoms of other elements to make new substances.

Theories are explanations that have been tested by repeat observations. Some of Dalton's theory has been disproved, but it was the beginning of the modern study of atoms.

There have been many modern inventions that helped scientists study atoms. Scientists can study the atom by breaking it up into electrons, protons, and neutrons. These small parts still cannot be seen. However, the path they leave can be photographed. It's a little like knowing a jet is in the sky by watching the path it leaves.

Inside the Atom

It is hard to imagine anything as small as an atom and that are made of even smaller parts. Except for hydrogen, atoms have *protons*, *neutrons*, and *electrons*. (Hydrogen is made only of a proton and an electron.) As discussed earlier, the center region of an atom, the nucleus, is made of



protons and neutrons. Around the nucleus are electrons. Electrons move around the center of the atom. Electrons do not move in fixed paths around the nucleus. The regions in an atom where electrons are found are called **orbitals**. The *orbitals* are within energy levels. Each energy level within an atom can hold only a certain number of electrons. The energy level closest to the nucleus—the lowest energy level—can hold no more than two electrons. The second energy level can hold eight electrons. There can be up to seven energy levels depending on the number of electrons in an atom. Electrons with higher energy are found in energy levels farther from the nucleus.

Each part of the atom is important. The proton has a *positive charge*. In math or science, a positive is shown with a plus (+) sign. A neutron has no charge.

protons have a **p**ositive charge (**+**)

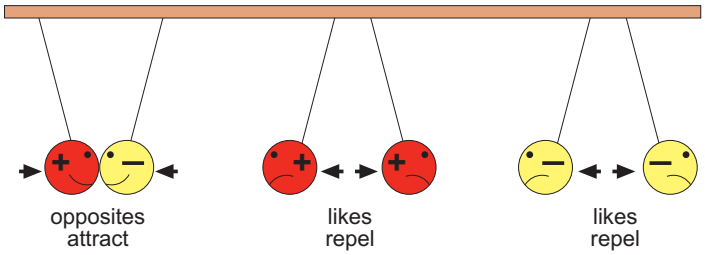
neutrons are **n**eutral (no charge)

electrons have a negative charge (**—**)

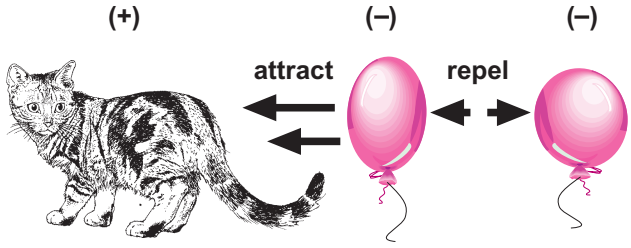
(Neutron sounds almost like **neutral**.) The electron that orbits around the center of the atom has a *negative charge*. Negative is shown by a minus (–) sign. The electrons are the part of the atom that react chemically with other atoms.

Electrical Charge

We said that a proton has a positive charge, a neutron has no charge, and an electron has a negative charge. What do we mean by the word *charge*? It stands for an electrical charge. Things that have the same charge push each other away or **repel**, but things that have different charges will move toward each other or **attract**. The forces that push and pull objects based on their charges are known as electrical forces. These electrical forces are often described by the phrase, "Opposites *attract*, likes *repel*."



Usually matter is *neutral*. It has no charge. In an atom, the number of electrons (–) equals the number of protons (+). It is possible for an electron (–) to be added to an atom. Rub two balloons filled with air on a piece of fur or wood. The atoms in the balloons pick up an extra electron atom from the fur. They now have a negative (–) charge. Place the balloons next to each other. They will move away from each other. Remember, two negatives (–) will push away from or repel each other. What about the fur? It has lost electrons. Now it has a positive (+) charge. Rub a balloon on the fur. The balloon is negative (–) and the fur is positive (+). The balloon should move toward the fur.



Opposites attract, *likes* repel.

Note: Results may vary with changes in humidity.

Summary

We have learned some important facts about atoms. We know that they are the smallest unit of an element that is still the element. Elements are made of only one kind of atom. We know they form molecules when they share electrons. We also know they combine with other atoms to make compounds. Atoms have smaller parts called neutrons, protons, and electrons. We learned that same or like charges move away from each other. Different or unlike charges move toward each other.

Practice

Use the list below to write the correct term for each definition on the line provided.

attract	**neutral**	**proton**
bond	**neutron**	**repel**
compound	**orbital**	**theory**
molecule		

_____ 1. two or more atoms that have a bond of shared electrons

_____ 2. the attraction that holds two or more atoms together

_____ 3. a substance formed when two or more elements combine chemically

_____ 4. an explanation that has been tested by repeated observations

_____ 5. the positively charged particle in the nucleus of an atom

_____ 6. the neutral particle found in the nucleus of an atom

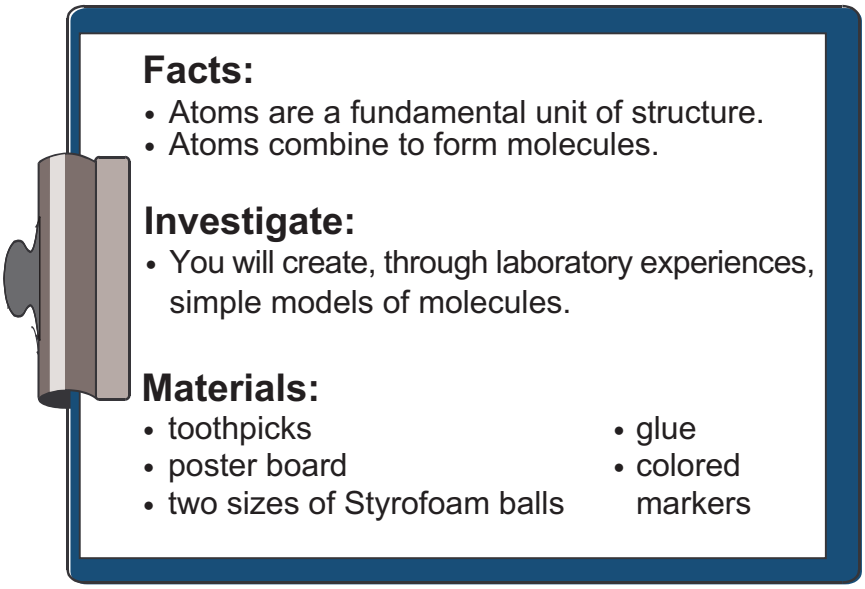
_____ 7. regions in an atom where electrons are found

_____ 8. being neither positively nor negatively charged

_____ 9. push away from

_____ 10. move toward each other

Lab Activity: Atoms and Molecules



Oxygen Molecule

We are going to build a model of an oxygen molecule. An oxygen molecule has two oxygen atoms.

1. Pick up two large Styrofoam balls. Each one stands for an atom of oxygen.

2. Label each ball with an O for oxygen. Remember that the O is the symbol for oxygen.

3. Place a toothpick in one of the O atoms. Connect the other O atom to the end of the toothpick.

   a. How many atoms are connected? _____

   b. Are the atoms the same? _____

   c. You have just made a model of a molecule of _____.

4. Glue the molecule to a piece of poster board.

5. Label your model "Molecule of Oxygen."

Water Molecule

Now we are going to create a model of a molecule of water.

1. Is water an element or a compound? _____
2. Since compounds are made from two or more different elements,we will need to use different kinds of balls in our model.
3. Choose one larger ball and label it with an O for oxygen.
4. Choose two smaller balls. Label each with an H for hydrogen.
5. Use toothpicks to connect an H atom to each side of the O atom.

   How many atoms are in the molecule of water? _____
6. Glue the model to a piece of poster board.
7. Label your model "Molecule of Water."

Illustrations

1. Draw a picture of your oxygen model in the space below. Label the atoms with the correct symbols.

2. Draw a picture of your water molecule in the space below. Label the atoms with the correct symbols.

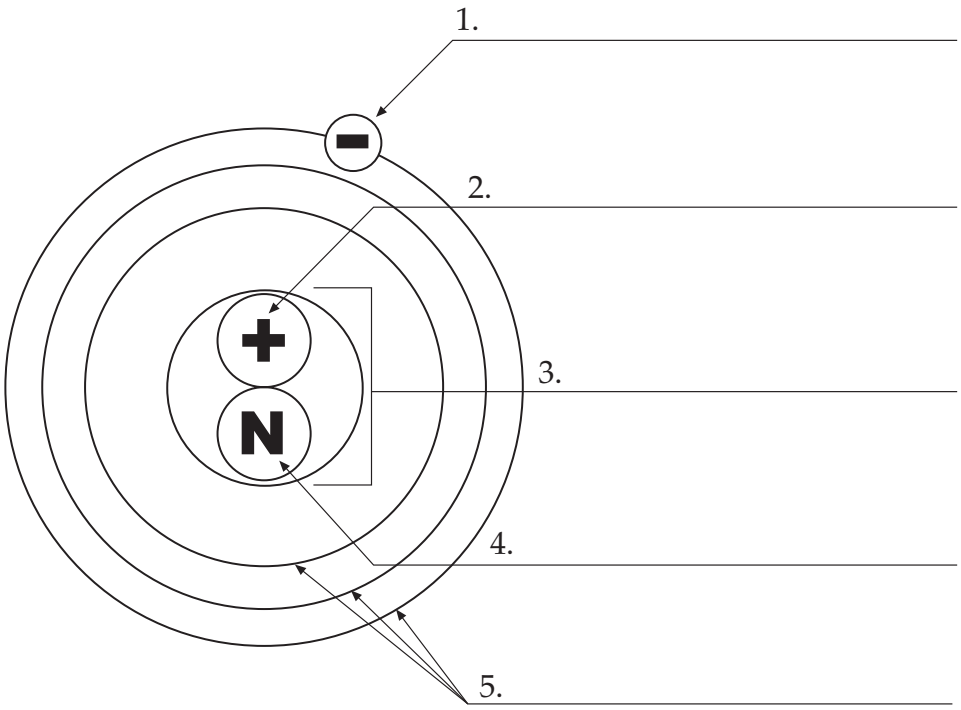
3. Which of the items represented the bond between the atoms?

_____

Practice

Use the list below to label the parts of the **atom** *in the diagram below.*

electron	**nucleus**
energy levels	**proton**
neutron	



Practice

The symbol ⊕ represents **protons**. *The symbol ⊖ represents* **electrons**. *Write what would happen if the two charges were placed near each other. Use the terms below to answer the following.*

repel (push away) **attract** (move toward each other)

_____ 1. ⊕ ⊕

_____ 2. ⊖ ⊖

_____ 3. ⊖ ⊕

_____ 4. ⊕ ⊖

Practice

Use the list above each section to complete the statements in that section.

atom	**distance**	**Greeks**
atoms	**forces**	**molecule**
Dalton		

1. As long as 2,000 years ago, the _____ were curious about matter.

2. About 150 years ago, _____ set up a theory that said all elements are made of atoms.

3. Dalton's theory said that _____ could not be split.

4. An _____ is the smallest unit of an element that is still that element.

5. A _____ is two or more atoms that share electrons in a bond.

6. When matter changes phase, the _____ between the molecules changes.

7. The behavior of these molecules is determined by the _____ that hold them together.

One or more terms will be used more than once.

apart	**nucleus**	**phase**
electrons	**orbitals**	**together**

8. Heat usually causes molecules to move _____ .

9. Freezing usually causes the molecules to slow down and move _____ .

10. Changes in _____ , like melting, are caused by gaining or losing energy.

11. Except for hydrogen, atoms are made of protons, neutrons, and _____ .

12. The center region of the atom is the _____ .

13. _____ move around the center of the atom.

14. The regions in an atom where the electrons are found are called _____ , which are within energy levels.

Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

attract	**farther**	**no**	**positive**	**toward**
away	**negative**	**one**	**repel**	

1. Electrons with higher energy are found in energy levels _____ from the nucleus.

2. The proton has a _____ charge.

3. The electron has a _____ charge.

4. The neutron has _____ charge.

5. If two positive charges were placed near each other, they would _____ .

6. If two negative charges were placed near each other, they would _____ .

7. If a negative charge was placed near a positive charge, they would _____ .

8. Like charges move _____ from each other.

9. Opposite charges move _____ each other.

10. Elements are made of only _____ kind of atom.